Other WORLDS than THIS

By Lloyd Fonvielle

OTHER WORLDS THAN THIS

UNIFORM WITH THIS VOLUME

HOW THE WORLD BEGAN
The Story of the Beginning of Life on Earth

HOW THE WORLD GREW UP
The Story of Man

HOW THE WORLD IS RULED
The Story of Government

THE WORLD OF ANIMALS
The Story of Animals

THE GARDEN OF THE WORLD
The Story of Botany

HOW THE WORLD IS CHANGING
The Story of Geology

THE WORLD'S MOODS
The Story of the Weather

THIS PHYSICAL WORLD
The Story of Physics

WHAT MAKES UP THE WORLD
The Story of Chemistry

THOMAS S. ROCKWELL COMPANY
Publishers
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Publishers' Note

This book presents in popular form the present state of science. It has been reviewed by a specialist in this field of knowledge. An excerpt from his review follows:

> *"This good effort to bring to younger minds some of the simple facts and laws of astronomy meets with my whole-hearted approval."*

Signed:

WILLIAM DUNCAN MACMILLAN

Professor of Astronomy
The University of Chicago

On the moon the earth would shine with a light forty times greater than moonlight

OTHER WORLDS THAN THIS

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Chapter I

HOW THE EARTH BEGAN

THERE was once a time when our earth did not exist. It was a very long time ago, thousands of millions of years ago, perhaps ten thousands of millions. No one knows exactly how long. The earth, the moon, Mars, Venus and all the other planets were a part of the Sun. And the Sun was traveling through space—alone.

What was the sun like before the earth was born?

Strange as it may seem, the Sun looked almost the same as it does now. It shone with the same fierce, white light. And it appeared to be exactly the same size. Even with all the planets a part of it, it could scarcely have been one-thousandth part bigger than it is today. If you yourself suddenly became one-thousandth part bigger, no one would be able to tell the difference.

As a childless star our Sun was one of a million lonely wanderers through the heavens. All around it was an empty space trillions of miles wide. The nearest neighbors were so far away they looked like pinpricks in the sky. Robinson Crusoe was never more alone than our sun on his desert island of space. Other stars, like ships that passed Crusoe's Island by, would come and go, but they never approached hailing distance.

The chances of one star meeting another were very small. But one day a new star appeared in the heavens. It seemed to be aiming straight at the sun. For thousands of years it kept coming closer and closer. It swept through the vast stretches of ether at a tremendous pace.

All this time our sun was traveling, too. The nearer the stars came to each other, the faster they moved. Horseshoe magnets come together with a click. But the power that drew the two suns together was not magnetism. It was gravity. Gravity is what makes the world go round. And it keeps the stars and planets

in their places. It has always existed and people have noticed it. Just as electricity has always existed and been noticed. But for centuries no one understood much about it.

An English astronomer, Sir Isaac Newton, was the first to discover what gravity's laws and principles were.

How did Newton discover gravitation?

When Isaac Newton was in his twenty-fourth year there was a terrible plague in England. All the schools and universities were shut down. During the long vacation that followed, he had time to think about many things. He wondered about the sun and the stars. And he wondered why the moon did not fly away from the earth, but kept going around and around it, like a weight on the end of a string that a boy twirls about his head.

One afternoon, so the story goes, he lay half asleep in an orchard. An apple fell from the branch directly over him. This everyday happening is said to have given Newton the answer to a question that had puzzled all the great astronomers before him. There and then he

is supposed to have discovered the law of gravitation. The story that astronomers tell us is a far different tale, a version not half so romantic or nearly so well known. It is, however, the true story of Newton's long hours of careful mathematical calculations.

What is the law of gravitation?

The law of gravitation is very plain. It is surprising that no one had ever proved it before. Everything in the universe attracts everything else. That is, every particle or piece, or body of matter attracts every other particle of matter. The force of this attraction depends on the size of the objects attracting each other, as well as on their distance apart.

How does the force of gravity work?

Let us think of these objects or particles of matter as so many men of different sizes. Some are giants three miles high. Others are as tall as a skyscraper. Some are average size. Others are four foot pygmies. Some are the size of Tom Thumb. And still others are no bigger than a flea. Then, suppose that a large number of ropes connect each man with every other man. Suppose, too, that each man is having a

tug of war with every other. Which man will have the greatest pulling power?

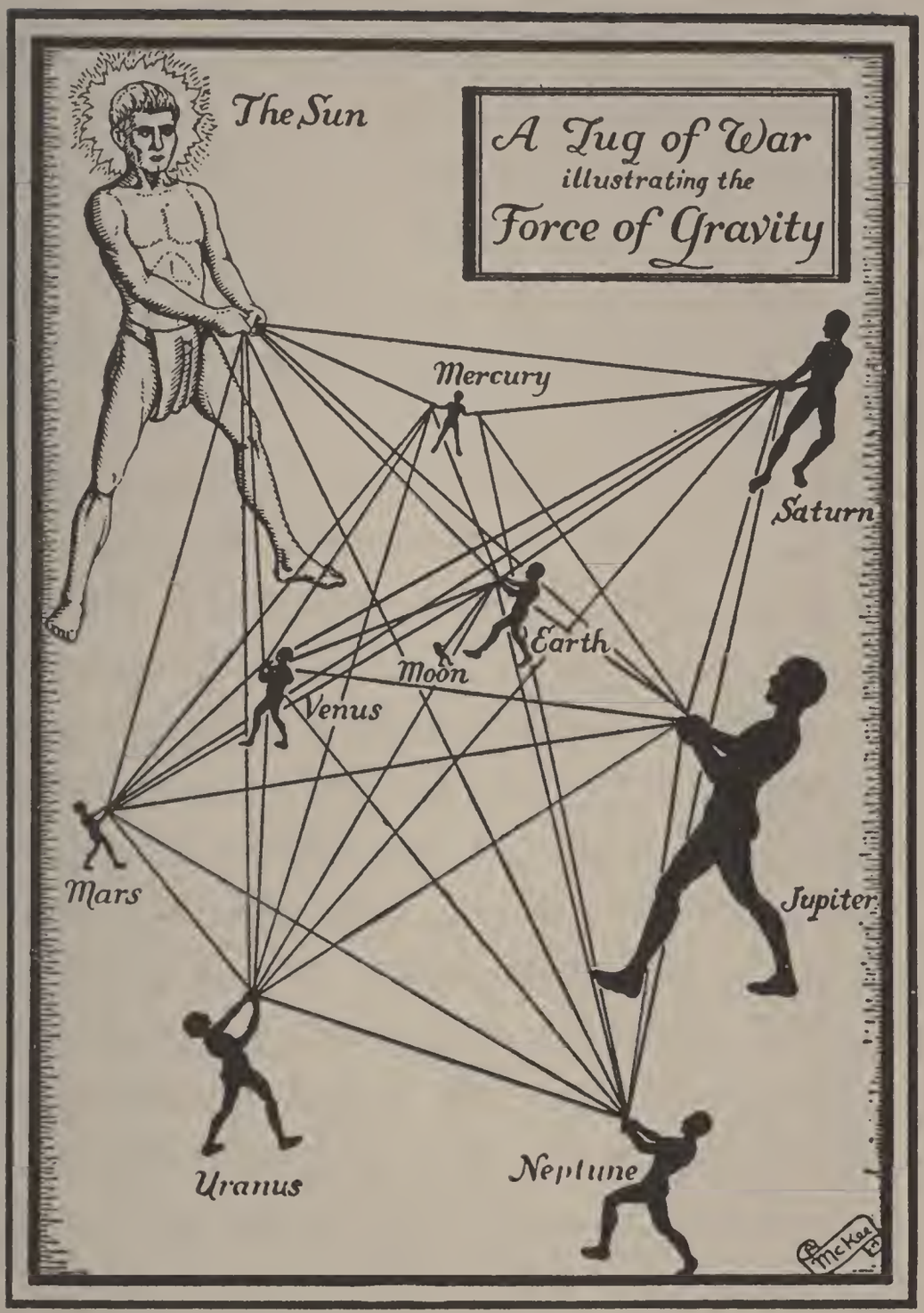
You know from experience how easy it is for a boy that is much bigger than you are to

This every-day happening is said to have given Newton the answer

pull you over. And it is still easier for him to pull you over if there is a short rope rather than a long rope between you. But lengthen the rope to a mile and he will not be able to move you one inch, no matter how hard he tugs. Now suppose your friend becomes a giant three miles high. He gives a jerk and there you go, flying toward him like a fish pulled in by a casting line or like an apple falling toward the earth.

In order to make it quite impossible for him to move you, you must place him several thousands of miles away. It is easy to see from this that the man with the greatest pulling power is not always the biggest nor always the nearest, but the man who is near enough for his bigness to count.

A boy your own size playing tug of war with a rope two yards long has more chance of moving you than a giant thousands of miles away. This is why the moon does not fall toward the sun but falls around and around the earth. It is also the reason why the planets do not leave the solar system for a bigger star but are forever falling around their parent sun. If the moon were nearer or the earth bigger, the earth would swallow the moon. And if the sun were bigger and nearer it would swallow the earth. Every star, every planet, and every heavenly body is pulling on every other one. They manage to keep apart and do not fall together in a heap because of the influence of their neighbors as well as their own pulling power.



The man with the greatest pulling power. is not always the biggest nor always the nearest

What was the sun made of?

Even in its childless days, our great white sun was gaseous. And so was its visitor. It was made up of tiny particles of matter, like a fog. If a stone could have been pitched through it without melting, it would have come out at the other side as easily as a bullet striking through a cloud.

What happened when our sun met the magnificent visitor?

When the two stars were near enough to feel each other's presence, the tiny particles of our sun were attracted by the newcomer. They swept toward it like a giant tide. As the two grew nearer, the tides became even bigger, and the bigger they grew, the more fiercely they whirled and spun. It seemed the suns had melted into one another. Actually they were still millions of miles away. A terrible battle followed. Each sun struggled to get free from the other. It was a real tug of war between enemies well matched in size and strength. But both were traveling at a terrific speed, and in opposite directions. Nothing could have stopped them except a head-on collision. They finally wrenched themselves apart. And each

strove for all he was worth to hold on to the millions of tiny particles that had left him for the other. Some of these particles our sun was able to pull back. But some were too far away. He could never force them to return.

What happened to the sun's lost particles?

Much as the children of Hamelin followed the Pied Piper the particles that left our sun followed the wonderful visitor. When he was alongside their home in the sun they shot straight out to meet him. But when he passed their home they had to cut corners so as to keep up. If you wanted to ride in an automobile that was coming down the street in front of your house, you would run directly out toward the roadway to meet it. But if the automobile passed you before you reached the street, you would cut across the yard to head if off. Now suppose someone ran behind you and put a pebble in every footprint. You would find you had run on a curve.

This is just what the particles of the sun did, too. They ran on a curve. When the visiting star finally got so far away that the particles

could not follow him any more, they found themselves in curved lines shooting out from the sun and revolving around and around it.

What is a spiral?

This revolving scattered material was like a mist of fire. But astronomers, being more interested in its peculiar shape, have called it a spiral. Spiral means a winding curve. Our sun's spiral happened to contain some particles bigger than others. These bigger particles had more "pull" or gravity than the smaller ones. So they gradually swept up the remaining and smaller particles just as a little snowball will pick up more snow and grow into a big snowball. Eventually the particles grew into planets of different sizes. They were not all the same size, because some were bigger to start with. And some of them traveled in parts of the sky where there were more particles to pick up.

As you may have guessed, one of the planets was our own earth. And this is the story of how our Solar System was created.

Chapter II

A BIRD'S-EYE VIEW OF THE SOLAR SYSTEM

THE Roman god of the Sun was called Sol. From his name we get the word Solar. The Solar System means the system of the sun. It includes the sun, planets, and the satellites or moons, which move around the planets.

Are planets like stars?

To most of us the planets seem exactly like stars. But suppose we were shepherds or astronomers and could watch them night after night for several months. We would be sure to notice a difference between them. In the course of the year, the stars rise, move across the heavens and set, traveling from east to west as the sun does. They march in a fixed order, as though on parade. But the planets seem to have an odd way of moving in respect to the rest of the pageant. Each one of them appears to have a road of travel all his own. This is why the

shepherds of ancient Greece called them planets or wanderers. We know today that the planets do not really wander because they all journey around the sun. But they move very slowly. So it not only takes months to discover that they are actually out of step with the stars but it takes years to trace their orbits.

Perhaps the quickest way of telling the difference between stars and planets is to look at them through a telescope. Under a telescope the planets appear much larger. They look like tiny moons, round and disc-like. But the stars, as the great Galileo once said, "appear of the same shape as when they are viewed by simply looking at them." They are merely bright points of light.

Then again, the planets shine with a steady, calm light and seldom change in color, while the twinkling stars will change all colors of the rainbow when seen near the horizon.

Why are planets as bright as the brightest stars?

Stars shine by their own light. But planets are really dark bodies. They shine only by the reflected light of the sun, as our moon does.

The reflected light is much fainter and less dazzling than direct light. If the planets were as many million miles away as the stars they would be completely invisible. It is because they are so much closer to us that their light seems as bright as that of the brightest stars. Our earth, seen from the other planets, would be like a star, too.

How many planets are there?

Besides the earth, there are seven other planets in the sun family. The earth's oldest brother is Mars. Her youngest is Saturn, unless we consider the newly discovered Pluto, about which astronomers are rather uncertain.

The names of the eight planets, starting with the nearest to the sun and moving outward to the next nearest and so on, are as follows: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Here is an easy way to remember the order in which they come. Separate the first letter of their names from the rest of the word. Then add new letters to the first letters so as to make new words. The next step is to form a sentence. You may want to make

your own sentences. But here are two ready-made, just in case you do not:

M-ark's V-exed E-mployer M-ade J-ohn S-tay U-ntil N-oon.

M-any V-icious E-lephants M-ove J-ungles S-eeking U-nfriendly N-atives.

Mars and Mercury both begin with M, it is true. But it is easy to remember why the planet nearest the sun was called after the winged messenger of the Gods. He travels around the sun in a much shorter time than any of the other planets. He takes only eighty-eight days. That means that his year is only as long as two and a half months of our year. Of course, he hasn't as wide a circle to travel around the sun, for he is only a third of the distance from it that we are. Stand a yard away from a tree and run around it. You will find that it takes much less time to get back to your starting place than if you stand three yards from the tree and, running at the same speed, keep three yards between you as you circle about it.

To get a clear picture of the differences in

size and distance of the planets, let us imagine we are going to build a miniature Solar System. Find a globe of the earth in the schoolroom and use this to start with. The earth is actually

How big are the planets?

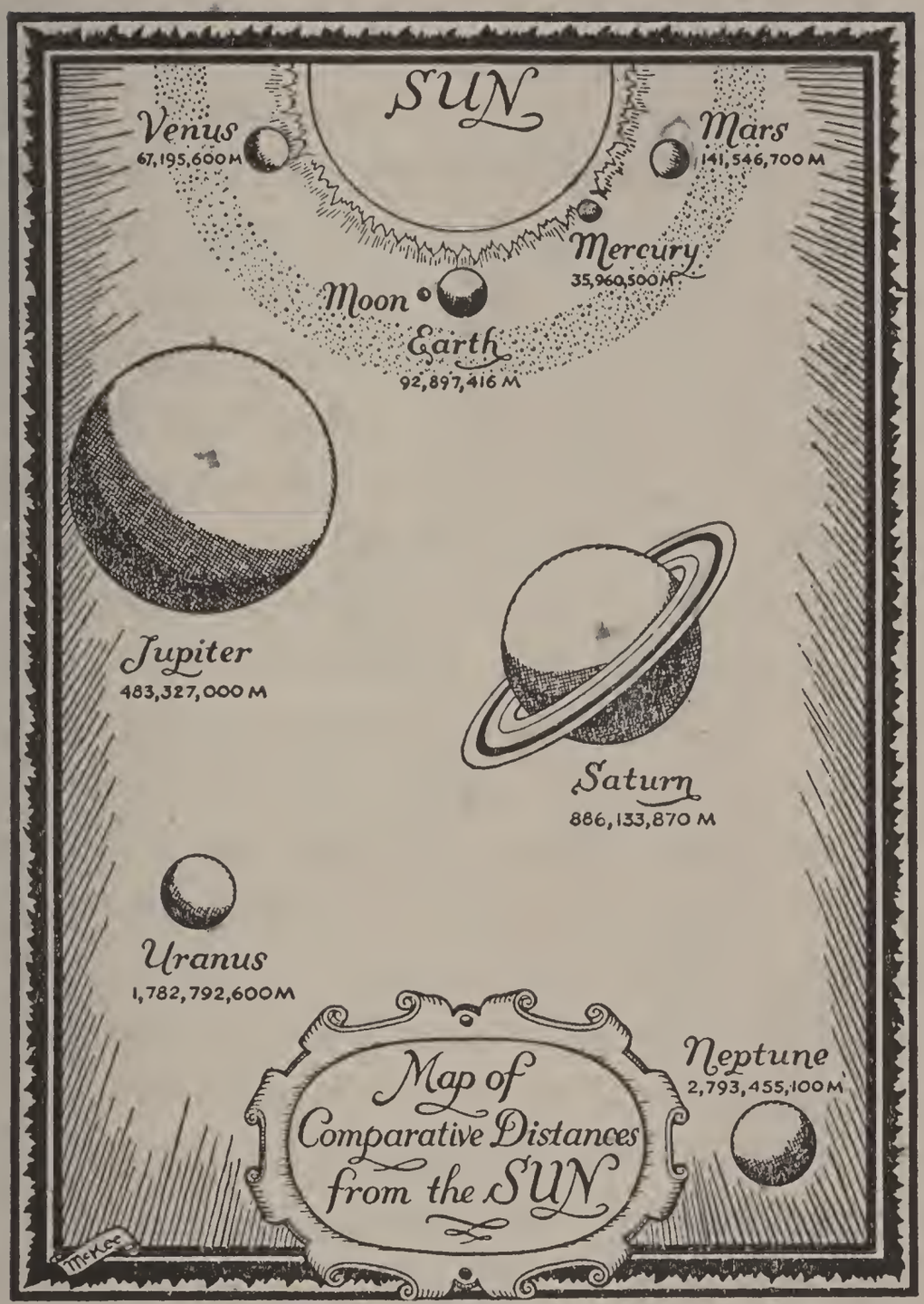
If you are only a yard from the tree it takes less time to run around it

over a hundred million times larger, because the globe is only half-a-foot high.

We figure that our sun, in relation to the six-inch earth, is going to be as high as a four-story building, fifty-four feet. So it is necessary to build our miniature Solar System in the school yard instead of in the classroom. Someone has a tennis ball, and that will represent Mercury.

Venus is another globe about the size of the earth, a baseball is what we want for Mars. A golf-ball will do for the moon. Jupiter is the first of the larger planets we are to meet. He is the biggest of them all, as a matter of fact. We must use a globe as tall as a man for him. Saturn is about the height of a boy ten years old (four and a half feet). But the rings around him occupy a foot and a half more. Uranus is about the size of a medicine ball (two feet in diameter). Neptune is two and a half inches higher. The moons of the other planets require several more tennis and golf balls, some marbles and a few grains of sand.

Now that all the members of the Solar System are lined up the next thing is to place them the correct distance from each other and from the sun. Our four-story sun has already been placed in the middle of the school yard. We can leave it where it is and turn our attention to Mercury. The tennis ball that represents Mercury is over a hundred million times smaller than the real Mercury. All the other objects



This map gives an idea of the distances of the various planets from the sun

used for planets are also a hundred million times smaller than the planets they represent. This being the case, we must reduce the distances between the planets over a hundred million times as well. Otherwise our miniature Solar System will not be a true model of the real Solar System—in perfect scale. Bearing this in mind, we quickly discover that it is going to be impossible to confine our miniature system to the school grounds. Mercury, the nearest planet of all, must be placed over a third of a mile away. Venus is going to be almost four-fifths of a mile distant. The earth is a mile and one-tenth distant, with the moon fifteen feet to one side of it. Mars is approximately a mile and a half from the sun. Jupiter is about six miles. Saturn is ten miles and Uranus and Neptune are twenty and thirty miles away.

We can tell by this that even so tremendous a sun as ours is dwarfed into nothingness by the four billion miles that extend from its heart to the outermost limits of the Solar System.

Chapter III

SECRETS OF THE SUN

THOUSANDS of years ago when anyone asked, "What is the Sun?" people answered, "The sun is the golden chariot of the sun-god. The sun-god drives across the heavens every day. He pursues the beautiful goddess of night. But he can never overtake her. She is swifter than the wind."

Today when anyone asks this question they are told, "The sun is the father of the earth. A tremendous ball of fiery hot gases. More than one million times as big in volume as the earth. And more than ninety-two million miles away. A glorious shining body around which the earth and the other planets revolve. The source of light and heat and life." How much grander is our idea of the sun today! And how much greater is our knowledge of it! In the

last hundred years astronomers have forced many of the sun's secrets from him. They have thus succeeded in painting a picture that is a thousand times more like the sun than any portrait made of him before.

What is the sun made of?

The sun is a fiery mass of metals and elements. Metals such as iron, nickel and aluminum, and elements like hydrogen, oxygen and helium. The heavier metals and elements are towards the heart of the sun. The lighter ones float around in clouds over its surface. Strange as it may seem, even the heaviest metals are in the form of gas. It is hard for us to imagine a gas of lead, platinum or gold, because we have never seen such a thing. As a matter of fact, there are few furnaces on earth hot enough to melt metals into gas.

How do we know the sun is made of gas?

We know the sun is made of gases for many reasons. But a most important reason is the fact that as it turns on its axis, some parts of it move faster than others. If the sun were as solid as the earth and not made of gases this could not possibly occur.

No one has ever seen the inside of the sun. But we know it is even hotter than the outside and the gases are thicker and denser. Toward the heart of the sun they have become so thick and heavy as to be much denser than water.

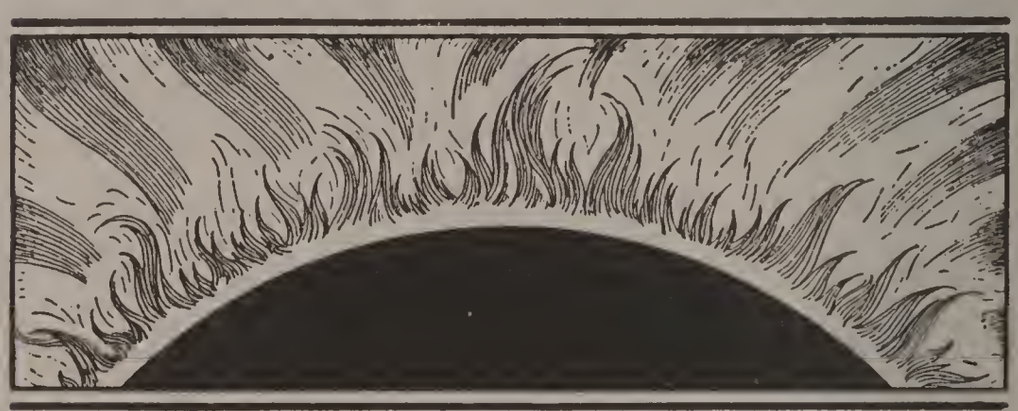
Is the sun the same on the inside as on the outside?

Next to this inner mass of gaseous material that astronomers know little or nothing about, is a region they have called the photosphere or lightsphere. It is made of lighter gases and is almost white in color. On top of the photosphere is a layer of gas almost ten thousand miles thick. It is called the photosphere or chromosphere, because it looks like a scarlet fringe of leaping flames. The tongues of flame reach up for thousands of miles. Some of the largest of them are actually eruptions. The outermost layer of the sun looks like a silver halo. It gradually fades into the dark stretches of ether. This is the reason it has been called the crown or corona.

Is the sun made of the same stuff as the earth?

The sun is made chiefly of materials found on the earth, although there may be elements in the sun that we know nothing about down

here. It is possible that in years to come someone may discover them, just as helium was once discovered. Helium was found in the sun long before it was known to be on earth. Since no one had anything with which to compare it, it was called helium, from the Greek word for



The outermost layer of the sun looks like a silver halo and is called the corona

sun. Helium is what many dirigible airships and giant balloons are filled with. It is the next to the lightest gas we know anything about. And it will not explode. There is more than enough helium in the sun to float an airship as large as the earth. There is enough aluminum to make a kettle big enough to hold the moon. The amount of silver in the sun is sufficient to

build a city the size of New York. And the great mass of iron would fill up our oceans to the brim if it could be poured into them. These as well as gold, mercury, and oxygen are among the forty or more elements that are found in the sun.

How hot is the sun?

We know that the temperature of the sun is very high. It is probably ten thousand degrees above zero at the surface. This is thousands of degrees higher than the hottest fire or furnace on our earth. If there were giants in the world and one of them chose to pick up the earth and throw it into the sun, the earth, skyscrapers, rocks, mountains and everything would melt into thin vapor in less than four hours. When we realize that the sun has been almost as hot as this, if not just as hot, for millions of years, we naturally wonder what makes it so hot as well as why it does not cool off.

What makes the sun so hot?

To find the answer to these questions we must first learn something of atoms and electrons. We have already learned that the sun is made of tiny particles of matter, like a fog.

These particles are made of still tinier particles called atoms. An atom is so small that no one has ever been able to see one. Even the strongest magnifying glass in the world will not bring it to light. In one pin point there are several thousand atoms crowded together. And there are as many atoms in a golf ball as there would be golf balls in the earth if the earth could be filled like a gunny sack.

Small as the atom is, it can be divided into something still smaller. This "something still smaller" is known as an electron. Electrons are of two kinds; positive and negative. An atom is made up of both kinds. And there are just as many negative electrons in an atom as there are positive.

The negative electrons hold in the positive ones and prevent them from escaping or turning into electricity. They surround the bundle of positive electrons like the sugar coating on a pill or like guards around a prison wall.

The atom is perfectly safe unless something happens to destroy the balance of positives and

negatives, or unless it is broken down by outside pressure. Ordinarily when an atom is broken down the electrons will go off in pairs; one positive and one negative, like prisoners handcuffed to their jailers. If they don't cancel each other (after the manner of an immovable object meeting an irresistible force), they will combine with other positive and negative electrons and form another atom.

But occasionally when an atom is disrupted there will be a head-on collision of a positive and negative electron. The positive will bury itself deep in the negative, like a hand grenade sinking into a shell-hole. What happens next? Both the positive and negative electrons disappear. In their place is a lot of liberated energy in the form of light and heat.

Now let us return to the sun and the reason why it is so hot. The sun is made of gases. But these gases are much thicker in the interior of the sun than on the surface. This is because they are made up of heavier particles than the lighter gases, particles with more atoms in them.

According to the law of gravity, heavier or larger particles have more pulling power than smaller particles and so they are generally in the thick or heart of things. In the case of the sun, the force of gravity is so great that it makes the separate particles in the heavier gases very heavy indeed. When they strike one another, as frequently happens, they exert a tremendous pressure. This pressure is sufficient to break down the atoms. And in breaking down the atoms, negative and positive electrons are released. As we know, these often collide head-on into one another and transform themselves into what astronomers call radiant energy or light and heat.

Why doesn't the sun cool off?

The law of gravity is a law that is always in operation and as far as any one knows always has been. So the atoms in the sun are constantly being broken up. But most of them recombine. Thus in a billion years or more there is very little change in the number of atoms in the sun. Those that do go off in light and heat are replaced by the stray particles that

the sun is constantly picking up as it travels through the great zones of space. Like all the other stars our sun feeds upon these stray particles "in exactly the same sense that cattle feed upon the grass of the fields."

We find here the reason why the sun has not cooled off during the lifetime of our earth. For the same reason it is not likely to die away or grow much cooler for billions of years hence.

What is an eclipse of the sun?

An eclipse of the sun is the hiding of the sun's face by the moon. About twice a year the face of the sun is hidden from the earth in this way. The moon passes between the sun and the earth and shuts off the sun's light. The moon is apparently big enough for the sun to hide behind. Actually the sun is many times too big to be hidden by the moon. It is only because the moon is so near us that it is able to screen us from the sun.

Hold a book at arm's length before you, so that it conceals any object you choose to cover—lamp, desk, or teacher at the other end of the room. You will see in an instant how a small

object can hide a large one if the large one is far enough away.

Where can a total eclipse be seen?

A total eclipse of the sun can be seen on only a small part of the world at one time. And since the eclipse is likely to be anywhere, one year Alaska, the next Africa, observers of eclipses must often travel great distances to see them. A man may travel two months to get to the best spot on the earth from which to observe a total eclipse. He may have spent twenty years collecting the money to pay the expenses of his journey. But the eclipse will last for only eight minutes at the most. More likely it will last for only three. Possibly it will be a cloudy day. Then he will not be able to see it at all. Why then, are astronomers so ready to risk time, money and even health for a few seconds of observation? What is there about a total eclipse of the sun that is so strangely fascinating?

What does an eclipse of the sun look like?

In the beginning an eclipse of the sun is like the darkening before a summer thunder-storm. Gray shadows gradually spread over the land-

At this moment in the eclipse the leaping flames of the sun's color-sphere are faintly visible

scape. Small animals hurry to shelter. The mother-hen drives her chickens into the coop and covers them with her feathers. A dog whines in terror. Birds fly restlessly from tree to tree, afraid and yet unwilling to believe their day is suddenly come to a close. As the sky darkens, their twittering ceases, and cautiously they find the way back to their nests. The fading of the light is slow and measured until the sun, half covered by the moon, is only a golden crescent. Then darkness sweeps in like the wind. The crescent sun becomes paler and thinner, a delicate thread of light one can look at steadily with the naked eye. This sudden darkness is alarming. It changes the color of everything. The grass and trees seem sickly—the line of the sky where it touches the earth changes from yellow to a greenish gray. We look at our friends. Their faces are ashen, like the faces of dead men.

Our sun is now only a flash of light that snuffs out like the lightning. In an instant it gives place to a halo of mysterious radiance, shooting

outward in icicle-shaped flashes. At this moment, too, the leaping flames of the sun's color-sphere are faintly visible. They encircle the outer edge of the halo like a pink afterglow.

Mercury, Venus, and the few stars close to the sun shine with the brilliance of night. This is the moment of moments, that miraculous second for which the astronomers have been waiting. But what are they doing?

What do the astronomers do during a total eclipse?

Are they standing spellbound, fixed in their places? No indeed. All of them are moving around, busy with a hundred seemingly trivial tasks. Some are drawing diagrams, others making calculations. Many are working with their telescopes. A few are looking into spectroscopes. Almost all of them are either taking photographs or making notes.

Why are astronomers interested in eclipses of the sun?

During an eclipse of the sun things can be seen that can never be seen at any other time, or, at least, not half so well. The sun's halo, or corona, is visible only during a total eclipse. The giant flames of the color-sphere are never so well defined as at this moment. Mercury,

the planet nearest the sun, is seldom seen very clearly at any other time. Mercury travels across the sky during our day and so it is outshone by the sun except for a brief period at sunrise and sunset.

In like manner, the stars that appear only in the daytime, or close to the sun, are generally outshone by the sun. An eclipse gives them a chance to introduce themselves.

Thus we learn from eclipses where the stars go in the daytime and what the heavens would be like if our day and night came at opposite times. From the observation of eclipses, astronomers have learned many of the sun's most important secrets: What the sun is made of, for example; how big it is; how dense it is; what its atmosphere is like; and what is in its neighborhood.

Chapter IV

A TRIP TO THE MOON

THE fact that no one has ever visited the moon need not prevent us from undertaking an imaginary trip there. Lucian, Fontanelle, Jules Verne, Abbé Moreux, Sydney Turner and Francis Godwin have given us authority for such a flight of fancy. After the journey we are about to make it may interest you to revisit the moon with the authors just mentioned. Once you have made the trip, all you will need in preparation are their books: *Above the Clouds, Conversations on the Pluralty Worlds, From the Earth to the Moon, A Day on the Moon, A Voyage Through Space,* and *The Man in the Moon.*

How far away is the moon?

The moon is our nearest neighbor. When closest to the earth it is only 221,000 miles away. Travelers like Burton Holmes have gone even

greater distances, though not at one time. The earth is not quite 25,000 miles around. Flying continuously the Graf Zeppelin could circle the globe in 26 days, 12 hours, not counting stop-overs; an average rate of 50 miles an hour. For our trip to the moon, however, suppose we choose the airplane that won the Schneider Cup Race. It holds a record of 337 miles an hour, but a rate of 300 miles would be a safer average to count on. Traveling at this speed, with no stops, we would reach the moon after four weeks and three days in transit.

What does the earth look like from space?

For days we have been steadily looking backward toward the earth while our pilot steers his craft straight ahead. We are fascinated by the strange sight of our earth growing smaller and smaller as it fades into the distance. No, fading is not the right word. After we have gone so far that we can no longer see the separate continents, the oceans and the polar cap, we notice that the earth is becoming luminous. It shines against a jet black curtain of space like a giant street lamp. Is it burning up?

Then someone assures us that everything is all right. The earth is only reflecting the sun's rays, as other planets and the moon do. But who would believe the earth could be so beautiful? We look toward the moon. It seems unimportant in comparison. As the days go by, however, the moon grows more interesting. We give up looking toward the earth, which is now only a lighted globe, and direct our attention to the moon alone.

What is a globe of the moon like?

For amusement we study a miniature globe of the moon. We are interested to discover a strip from pole to pole, a little less than a half of its area, entirely blank. This is because astronomers on earth have never been able to see this section of the moon. Our satellite, as it happens, turns only one side of its face towards the earth. Fortunately, astronomers have been able to see a little more of its surface than just this one-half. Slight variations in the rate of its revolution give short glimpses of the other sections. What it *is* possible to see on the globe proves unusually fascinating. Enormous moun-

tains and chains of mountains, vast craters, gigantic canyons, and tremendous plains!

Everything has a name. We recognize most of the names as belonging to famous earth-men, astronomers and philosophers. Aristotle, Plato, Herodotus, Copernicus, Ptolemy, Kepler, Leibnitz, and Grimaldi are all included, some because they discovered the objects their names are attached to, others because of their interest in astronomy or their financial support. We name parts of our earth in the same way; America, Washington, Pikes Peak, Pennsylvania, Virginia, Carolina, for example.

It may be well to interrupt our journey at this point. Let us pause to thank fortune we are not undertaking an actual trip to the moon. Imaginary travels have some very real advantages. Take our present journey from the earth, through space. The temperature of space is 450 degrees below zero. And since it does not reflect light it is pitch black as well.

What is space like?

The earth's atmosphere extends less than three hundred miles upward. This means that

Our moon turns only one side of its face toward the earth—the other is invisible

beyond it there is no air to breathe. And sound does not exist. A person actually attempting such a journey would discover that the fastest airplane could not move one inch through space unless it was surrounded by some sort of atmosphere through which the propeller could thrust its way. Since the force of the earth's gravity extends far beyond its atmosphere, the airplane, supposing it could reach such a point in space, would gradually slip toward the earth, falling faster and faster the closer it came. Its attempt to fly to the moon would be a failure. In the meantime our aviator would have suffocated, provided he had not frozen to death first.

What is the surface of the moon like?

When we are about 23,000 miles from the moon, approximately the distance around the earth, the speed of our plane increases to a marked degree. Our pilot cuts off the motor, and we glide peacefully forward. We are now at a point where the attraction of the moon is greater than that of the earth. The moon is gently pulling us toward her. The nearer we get, the faster we go.

Now we can plainly see her dark plains and bright mountain tops. Some of the mountains lie in gigantic chains, extending for hundreds of miles. Their peaks are as tall as the peaks of our highest mountains. But they look much bigger because the moon is very small in proportion. The mountain chains are cut by tremendous gorges, deeper than the Royal Gorge and by valleys so thin they look like slits. Vast plateaus and plains, at one time thought to be seas, cover a large part of the moon. From their midst and along their edges rise mammoth craters. Many of these craters, or cup-shaped cavities, have walls three or four miles high. From our position just above the moon they look like pock-marks on its face. The surface is rough, grim, and forbidding.

Our pilot signals that he intends landing in Copernicus, because the surface to the north of its central mountains is remarkably smooth and free of craterlets. Copernicus is one of the biggest and best known of the lunar craters. He circles around it, a distance of almost 176

miles. The walls are almost two miles high. A lofty mountain, twenty-four thousand feet from the plain to the tip of its topmost peak, rises from the center. It looks for all the world like a collection of ice cream cones on a giant platter.

What is the climate of the moon?

Suddenly the rocky surface of the moon rises up to meet us. Here, at last, after a month's journey we are on the moon. We get out to stretch and sniff the air. Only there isn't any air, and we can't sniff. The icy arms of space encircle the moon. We make the sad discovery that the moon has no atmosphere whatever. This means that it never rains on the moon. It never snows. Rainbows are impossible. Sunrise and sunset are without colors, other than primary. The sky is neither blue nor grey, nor any shade at all but black. With no atmospheric blanket to protect it from the sun's rays, the naked rock-surface of the moon is heated to the boiling point. In the blinding glare, objects of the lunar landscape have the sharp edged look of white silhouettes.

The sun has never seemed so brilliant or so blue. And yet stars can be seen up to its very rim. There must be several thousand more than are visible on earth. The heavens are crowded

What does the sky look like from the moon?

Many of the cup-like craters of the moon have walls that rise two miles high

with them. It is a magnificent sight. But the most interesting object of all is our own planet, the earth. It sways slightly to and fro over our heads and seems as big as a basket ball. The light from the earth is far greater than the

brightest moonlight on a Californian mountain-top. It is forty times as bright. The sight of it makes us a little homesick. So we turn our attention to other things.

How strange that we can see for only such a short distance! The walls of the crater are quite invisible unless the sun is shining directly upon them

How far could we see on the moon?

But we know they are there, for we have just seen them. Our pilot tells us that the reason we can see no farther is because the moon is so much smaller than the earth. Objects any distance from us are on a curve below our line of vision. If the earth were one-fourth as large as it is, or as small as the moon, we would see the masts of ships disappear when they were only six miles out at sea instead of twelve.

Turning suddenly, we are astonished to find our fellow travelers leaping high into the air. Apparently they do this with the greatest ease. We take a step toward them and find ourselves doing the same thing. There was never a pleasanter sensation, the steady slow ecstasy of

motion one dreams about only to waken and find one has fallen out of bed. Jumping clear over the heads of one's friends is no trick at all. Unless they are attempting to jump over somebody else at the same moment. Anyone who has ever seen a slow-action motion picture will have a good idea of the strange appearance these leaping earthmen present.

Is there moon magic?

Moon magic is not the name for this delightful buoyancy. But the law of gravitation is. Because the moon is smaller than the earth and because it is made up of lighter particles, its pulling power is only one-sixth that of the earth. Fortunately, the force of gravity depends on density as much as on size.

Here are a few of the things we could do on the moon. We could strike a baseball so that it would reach a fielder almost one-third of a mile away. We could lift a horse. We could jump over a rock as high as a three story house. We could throw an apple up in the air and easily fill it with darts before it would touch the ground. Or we could play a game of tennis

with a net thirty feet high and a court the size of a football field. During our month's stay on the moon we have plenty of opportunity to do all these things. But the novelty soon wears off.

What is a night on the moon like?

In the course of time we discover another strange thing about the moon. Its month and its day are exactly the same length! Imagine a day two weeks long! And a night two weeks long! The setting of the sun occupies one-half of an entire earth day. And another twelve hours is required for the sun to rise. With the coming of night, intense cold sets in and a darkness like that of midnight. There is no such thing as twilight, because of the moon's lack of an atmosphere to reflect the lingering rays of the sun. And there is no such thing as a temperate heat or cold, because a protective air-blanket is missing. Two hours after sunset the moon's temperature has fallen below the freezing point. Forty-eight hours later it is almost one hundred degrees below zero, even colder than Byrd found it at the South Pole. This intense cold continues until sunrise the following

lunar day. The reason for the long lunar night and day is this: As the moon travels around the sun, it turns very slowly on its axis. One side of it is thus exposed to the rays of the sun for a great length of time.

During the long lunar night we occupy ourselves by watching the earth, sometimes with a telescope, sometimes without. We see the earth rotating on its axis overhead. Through the telescope we can distinguish its oceans and continents. They move from west to east and around again, endlessly appearing and disappearing. We notice too that the surface of the earth is almost hidden by clouds. They swirl and eddy before the wind in the most engaging fashion. Parting here and there they reveal a strip of green forest or ocean.

Why does the moon change from crescent to full moon?

Although we cannot see the sun, we are able to see its effect on the earth. Sunrise and sunset progress in orderly fashion around the globe. Darken the schoolroom, then get someone to direct a flashlight at a globe of the earth revolving from west to east. Now walk slowly

around the revolving globe, west to east, as the moon does. Then you will see just how the earth changes from full earth to three-quarters earth, to half earth, to quarter earth, to no earth, to new earth, to half earth, and all over again. In other words, the earth as seen from the moon goes through the same phases that the moon does as seen from the earth. The constantly changing appearance of the moon is due to its constantly changing position in respect to us and the sun. There are times when the moon is quite invisible because the sun is shining on the side we never see. When there is a full moon, it is shining only on the side facing us, and when there is a half moon, it is shining partly on the side we do see and partly on the side we don't see.

What are the scenic wonders of the moon?

We wait until the sun is well overhead before taking our departure from Copernicus. Before leaving the earth's satellite, we intend making a short inspection of its scenic wonders. And we want to be able to see them in the best light possible. Rising from Copernicus, then, we

travel in our airplane north across the so-called sea Imbrium (Sea of Showers) to the Crater Plato. The walls of Plato rise as high as seven thousand feet in some places and surround a pit bigger than the state of Delaware.

From Plato we fly south and to the right until we reach Aristarchus. This is indeed a glorious sight, the most brilliant crater on the moon. It is with some reluctance that we leave it for Grimaldi. Grimaldi, we are told, is the darkest lunar object of its size. But when we finally get there, we are more than glad to have come. This somber crater is so gigantic that it could easily contain the entire kingdom of Denmark. Skirting one side of the plateau, Mare Humorum (Sea of Vapors), we pass over the crater Gassendi on our way south to Tycho. Gassendi is only interesting for the many crevices in its walls, so we waste no time over it. Tycho, on the other hand, is a magnificent crater over fifty miles wide and nearly three miles deep. A mountain more than a mile high rises from its center.

Following a closed crack in the moon that runs out from Tycho and extends for hundreds of miles north, we are led directly to the crater Theophilus. Theophilus is the deepest crater in the moon, almost four miles deep. In the center of Theophilus are three lofty mountains well over three miles high. Their altitude is so overpowering that we are glad to be flying still farther north to the Sea of Serenity. From the left edge of Mare Serenitatis, the Apennine Mountains jut out. They point directly to Copernicus. Back at Copernicus, we waste no time, but depart immediately for the earth.

Are there people in the moon?

Of course, all of us know there is no such thing as the man or the woman in the moon. But the question naturally arises, "Are there people of some sort living up there; is our beautiful satellite inhabited?" It is, perhaps, just as well to decide this question for ourselves, since our recent visit has made us familiar with the moon's climatic conditions. Whatever we decide, we need never deprive ourselves of the fun of finding the man, woman or hare in the moon.

Unless you were born in the Far East you have probably never heard of the hare in the moon. It seems, according to a Hindo legend, that Buddha in an early incarnation had the appearance of a hare. His best friends were an ape and a fox. One day, as they were walking together, they met the great God Indra disguised as a beggar. He asked them for food. Very willing they all set out to get him some. The fox and the ape each returned with a generous supply of choice morsels. The hare was not so successful. He came back empty-handed. Not to be outdone in hospitality, he built his guest a fire and threw himself into the flames, thus offering himself for the roast. The God Indra was so touched by this sign of devotion that he granted him eternal life and placed him in the moon. If there is a full moon, and you look very carefully in the center of it, perhaps you will be able to see him now.

What about the hare in the moon?

The man in the moon is much easier to see. But the most that can be said for him is that he is not handsome. Besides, he has a bad repu-

What about the man in the moon?

tation. The story goes like this: A fairy wandering aimlessly over the countryside one Sunday morning came face to face with a man carrying a load of sticks. "Why do you work on the Sabbath?" said the fairy quite sternly. "Sunday on earth or Monday in heaven, it's all the same to me," said the man. At this the fairy grew very angry. "Then carry your bundle forever" she cried. "You shall never see a Sunday again. From now on you are going to travel with the moon where it is always Monday." (Moon-day.)

What about the lady in the moon?

The lady in the moon is plainest of all to see. Once you have found her, it is hard to see either the man or the hare. She looks like a Gibson girl with a pompadour over her forehead. But she is much older than the Gibson girls, older, in fact, than the very first girl on earth. In ancient Peru, the Indians said she was a beautiful Inca maiden that had fallen in love with the moon and had thrown herself into his arms.

Chapter V

OUR NEAREST NEIGHBORS.

THE earth's nearest neighbors are the planets Mercury, Venus, and Mars. They, and the earth, are known as the terrestrial or minor planets. This is because they are the smallest planets in the Solar System, as well as the ones nearest the sun. Compared to Jupiter, Saturn, Uranus and Neptune, they are very close together. The entire group could sit comfortably between any two of the bigger planets and still leave room for another group just as broad. If we think of the distance between the sun and the frontier of the Solar System as a highway one mile long, the earth is one-thirtieth of a mile along the road. Mars is a twentieth the distance, or five per cent.

The terrestrial planets may be classified as minor, but they have at least one outstanding

feature. They are near enough to the sun to receive the fullest measure of its light and heat.

Which planet is smallest?

Mercury is a pigmy planet, the runt in the Solar family. As we shall see later, it is even smaller than one of Jupiter's moons. It is only a half bigger than our moon. Nevertheless, it holds the place of honor nearest the sun, the inside track in the everlasting race around it. On an average it covers a distance of thirty miles in one second. Traveling at this rate it takes only eighty-eight days to complete its circuit. This means that its year is a little less than three months long.

How does Mercury look from the earth?

From the earth, Mercury seems like a star of the first magnitude. It shines with a brilliant white light. But it is seldom seen except at sundown and sunrise. Even so, it is visible for only a short period during the year. This is because it is so close to the sun.

If we were to observe Mercury through a telescope night after night, we should see it go through the same phases as the moon. We should see it pass from new Mercury to quarter

Mercury, to half Mercury, to full Mercury, and so on. And so we know that this tiny planet has no light of its own. It is dependent on the sun for its brilliance, just like our moon. It is like the moon in still another way.

Why is a day a whole year long?

Mercury keeps the same side toward the object it travels around, and as it circles, it turns only once on its axis. You remember that the moon pivots around the earth while, at the same time, it circles the sun. But Mercury pivots only around the sun. So the moon's day and month are the same length, while Mercury's day and year are the same. Mercury is a planet without a satellite and for this reason it has no month whatsoever.

Is Mercury a two-faced world?

The consequences of all this are quickly apparent, if we travel with Mercury around its orbit. That half of Mercury facing the sun is always light. The opposite half, turned away from the sun, is always dark. Thus on one side is everlasting day. On the other side is everlasting night. Connecting the halves are two in-between zones like the seams on either side of a

ball. These sections have only one night and one day during the whole year. Sunrise and sunset are both in the east because the sun never rises very high in the heavens. It drops back to where it came from, rather than completing its journey across the sky. Instead of a real day, there is a gloomy, all pervading twilight.

What is the climate of Mercury?

Someone has called Mercury a study in black and white, because one-half is dark and one-half is light all of the time. It has little atmosphere, if any at all. Atmosphere has the wonderful power of splitting the sun's white rays into different colors. Without it, only simple colors, or red, yellow, green and blue, would exist. But Mercury's lack of atmosphere also has a very terrible result. It makes this small planet boiling hot on one side and freezing cold on the other. If Mercury had both a deep and dense blanket of air, it might then be protected from these extremes of heat and cold. Warm winds from the bright side might then sweep over the dark side. And cold winds from the dark side might blow over the light side. If

this were the case, and there was plenty of water, life in some form might exist. As it is, the side toward the sun is forever exposed to its burning rays. They beat down upon its surface with an intensity of light and heat from four and a half times greater to nine times greater than on earth.

Imagine a mid-summer day on earth, 90 degrees above zero. Then multiply by four and one-half. You get a mid-winter day on Mercury, 405 degrees above zero.

If you are not already fried to a crisp, try imagining a day on Mercury six weeks later. This baby planet is now thirty million miles nearer the sun than it was before. The sun looks two and one-half times bigger. It seems as large as a small yacht. And it swings directly overhead, slowly to the right and then to the left, like a pendulum. The rocks and stones are sizzling under a temperature of 810 degrees. This is well over the boiling point of lead. What little water there may have been on this side of the globe has quickly turned into steam.

But during the next six weeks Mercury will grow cooler. The sun will gradually diminish in size until it seems no bigger than the arms of a windmill in motion.

Why is Mercury twice as hot in summer?

There must be a reason for these sudden climatic changes. Astronomers tell us that they are due to the shape of Mercury's orbit which is a long, narrow oval. For a period of forty-four days, Mercury plunges toward the sun. But it falls in a curve instead of a straight line. During this tremendous plunge of fifteen million miles it gains considerably in speed. At length it is moving thirty-six miles a second, or about five hundred times faster than the fastest airplane. When it has reached this rate of speed, it is ready to swing abruptly around the curve of its orbit closest to the sun. If it were going much slower, the sun would be able to pull it back on to its surface. Once the dangerous curve has been passed it gradually slows down to twenty-four miles a second and it rounds the outer curve at this rate. Then, the outer curve having been weathered, the long

plunge commences all over again. It goes without saying that when Mercury is traveling its fastest and is nearest the sun, it is much the hottest time of the Mercurian year. In like manner its coolest hours are reached when this baby planet is leisurely rounding the outer curve.

Due to Mercury's dual nature its peculiar orbit affects only its sunward side. The other side is lost in a darkness so profound that nothing but a change of axis could cause the slightest difference. While the sunny face of Mercury rises several hundred degrees in a period of six weeks, the dark side remains about the temperature of space, 450 degrees below zero.

Which is the evening star?

For many people, Venus is the favorite planet. Certainly it is one of the most beautiful. Seen from the northern hemisphere, it outshines every other stellar object in the heavens. Its light is sometimes golden, sometimes silver; according to the state of the atmosphere. It is like a beacon of friendliness, a magnet that

draws all eyes in its direction. Perhaps you already know Venus. She is sometimes called the morning star, and then again, the evening star. Like Mercury, Venus is so close to the sun that she makes her appearance with it. She is much nearer the earth than Mercury. And she is several times larger. So she appears much brighter and more beautiful. Unfortunately, Venus is an infrequent visitor. Between her disappearance and her return there is a long period of a year and seven months. During this time she has been traveling so close to the sun that she is completely obscured by its glare.

Why is Venus the earth's twin?

Venus has often been called the earth's twin. An observer from another planet would certainly think she was. Her light at such a distance is no brighter than the earth's The similarity, however, does not rest here. The earth and Venus are much the same size. Venus, according to recent measurements, is only 327 miles smaller in diameter than the earth. And her mass is practically the same. Moreover, Venus has an atmosphere. This

atmosphere is cloud-laden. This outer layer is just above freezing, but the surface may have a temperature similar to that of the earth. No instrument has ever measured the inner layers. It is probably cloudy enough to protect her from the double amount of light and heat that she gets from the sun. If this is so, the atmosphere may contain oxygen as well as vapor. Then she is in condition to support life.

Is Venus inhabited?

With the stage set for life, and many noted astronomers, such as Moulton, incline to the belief that it is, more than likely there are living beings to act upon it. This being the case, what are the Venusians like? And what sort of world do they live in? There being no direct evidence to the contrary, we can truthfully say that conditions seem favorable for the existence of beings somewhat like ourselves. However, we should not expect them to be twins with the human race. Perhaps they are taller than we earthmen. There is a possibility that they could support large bodies without discomfort, because they would weigh less. The force of

gravity is fifteen per cent less on Venus than on earth. But we must remember that the air is thinner and would counteract most of the difference. Then again, a warm climate usually breeds a short-legged race of men. And we have reason to believe that Venus is a land of perpetual summer.

What is the Venusian climate?

As Venus journeys around the sun, she steers her course by her axis. The axis—an imaginary line running through the north and south poles—seems to stand upright on the road of travel. Every twenty-four hours, according to recent observations, she makes a complete turn around it. It would seem as though she were boring her way through space like a turning screw. With an upright axis, all parts of a globe are exposed to the sun's rays during the day, every day in the year. The amount of sunlight each part gets never varies. This means that if Venus does have an upright axis and if she does revolve around it every twenty-four hours, she has absolutely no change of seasons. Where it is winter, it is always winter, and

If Mars is inhabited, its people can comfortably support bodies fourteen feet tall

where there is summer it is always so. Under such circumstances summer on Venus would range from areas of perpetual springtime to tropic zones and cover by far the greatest part of the globe. If we could stretch the combined states of California and Florida like a piece of leather to cover a planet the size of Venus, we might get a pretty good idea of what her climate is like. It is safe to say that the garden spots on Venus would rival the best that California or Florida has to offer. Trees would be taller, vines would climb higher, and flowers would be bigger and brighter in every way.

What would the earth look like from Venus?

Before we let imagination run too far, suppose we investigate Venus' outlook on the world. Astronomers say it is the best in the whole Solar System. They take for granted, of course, that Venus' atmosphere is not dense enough to hide the heavens.

Looking out from Venus, the most brilliant and by far the most interesting thing in the whole night-sky is Venus' twin sister, the earth, and yet, despite its nearness, the earth is never

as bright to the Venusians as Venus is to us earth-men. This is because the earth gets no more than half as much sunlight as Venus. And its atmosphere being thinner, its powers of reflection are so much the less.

From this distance the moon and the earth appear to be a magnificent double star. The moon is forty times fainter than the earth. But even so, it is more than six times brighter than the brightest star. Astronomers on Venus would be able to see the side of the moon that is turned forever away from the earth. They would get an unusual view of an eclipse of the sun by the moon. And they would see an eclipse of the moon by the earth's shadow as plainly as a movie in a darkened hall.

What do the other planets look like from Venus?

As on the earth, Mercury is a brilliant, irregular morning and evening star. The advantages of being a near observer of Mercury would probably be offset by the increased dazzle of the sun. Venus' greatest opportunity for observing Mercury would occur during one of its transits across the sun. At this time, Venus,

Mercury, and the Sun would be directly in front of each other. Venus would thus see Mercury silhouetted against the sun and could observe in detail its outer hemisphere. In like manner our supreme moment for the observation of Venus is when Venus is silhouetted against the sun and moves like a tiny black beetle across it. Most unfortunately for us, a transit of Venus occurs at rare intervals of a hundred years or more. Few of us will live to see the next one, which is scheduled for June 8, 2004.

If Mercury and Venus were large enough to cut off the light of the sun, their transits would be called eclipses. The same principle underlies both.

Mars, as seen from Venus, would be a dependable but inconspicuous object in the heavens. It would be many times outshone by the moon. The other planets would appear much the same as they do on earth.

With such a magnificent outlook on the world, we would naturally expect the Venusians to be great astronomers. But should we

do so we would deliberately ignore one of the few certain things about this planet, her dense atmosphere. Venus' atmosphere is said to be anywhere from one and a half to two times as cloud-laden as the earth's.

We must therefore conclude that the clouds which continually hang over the Venusian landscape hide the heavens even more effectively than the clouds in our own sky. The supposed inhabitants are, in all likelihood, as ignorant of the earth as they must be of the other planets and the stars. Nor is this all. They may never have seen the sun. Instead of a sun there is probably a strange, diffused glow of unbelievable brilliance. To us it would seem as weird and artificial as the lighting for a futuristic stage setting.

Could men live on any other planet?

Of all the planets Venus is the best suited to bear life. But Mars runs it a close second. Seen with the naked eye, it appears to be a star of the first order of brightness. It shines with a ruddy glow like the embers of a dying fire. Sometimes it is very close to us. Then it

completely dominates the firmament with its brilliance. Do you wonder that the ancient Greeks called it Mars, after their God of War?

Through a telescope, Mars loses most of his threatening appearance. It drops from him like a mantle. Behold a beautiful round disk much smaller than the earth—greenish blue and yellowish red lines swirl around and across it. Here is the beauty of a Chinese marble.

How does Mars differ from the earth?

The atmosphere on Mars is many times rarer than on earth. Its surface is seldom hidden by clouds or fog. An astronomer by the name of Lowell was thus able to construct a miniature globe of this planet. The globe is wonderfully complete in detail. Now and again we read in the newspapers about a rocket that is going to be shot to Mars. If someone were really shot to Mars in a pneumatic tube of this sort they would be as well supplied with directions for finding their whereabouts as the tourists of California are with road maps.

Mars is a small planet, little more than half the size of the earth. Its density is about three-

fourths of the earth's. So its pulling power is little more than a third the pulling power of our planet. A boy weighing one hundred

Through a telescope Mars becomes a beautiful disk, with greenish blue lines across it

pounds on the earth would weigh only thirty-six pounds on Mars. If Mars is inhabited, its people can comfortably support a body fourteen feet tall.

By watching the appearance and disappear-

ance of certain set features on its surface, it was discovered that Mars rotates on its axis once in every twenty-four and a fraction hours. Day is, therefore, about the length of our day. The seasons are much the same as ours, too. Take a globe of the earth and place it on a chalk line representing its course around the sun. You will see that the rod running through the axis makes one side of an angle. The chalk line forms the other side. A globe of Mercury placed in back of the earth would tilt toward the line of travel with approximately the same slant. The earth's seasons are due to the slant of its axis. Since the slant of Mars' axis is the same, his seasons must be the same too.

But it happens that Mars is forty-eight million miles farther away from the sun than the earth is. So it travels over a much larger circle. Moving very little faster than the earth, it takes almost two years to get back to where it started. Accordingly, Mars' year is about two of our years. And its spring, summer, fall and winter are all nearly six months long.

When we speak of seasons, we must not forget that Mars receives one-half as much sunlight as the earth. Its blanket of atmosphere is also very thin. So while the days may be fairly comfortable, the nights are freezing cold. Even at the equator it must be way below zero after sundown.

What is the climate of Mars?

But it's an ill wind that blows no one any good. The rare atmosphere and bitter cold combine to give Mars a glorious view of the heavens. Stars seem much bigger there than here. And instead of one moon to watch there are two, Phobus and Deimos. The horses which drew the chariot of the great war god Mars were called Deimos and Phobus, so these satellites are well named. Phobus, the larger, is no more than ten miles wide. Deimos is only five or six.

What are the moons of Mars like?

These baby moons are so close to Mars that it takes the nearest only seven and one-half hours to circle around him and the other only thirty hours and eighteen minutes.

Both the planets are too small and their pull-

ing power too weak to hang on to an atmosphere of any kind. But for the minute let us suppose a man *could* live on Phobus, the larger. The force of gravity would be so slight that he could easily support a body two-thirds of a mile tall. And an ordinary sized man would be able to jump a thousand feet into the air. Coming down he would float as lightly as a feather and touch the ground just as gently. According to Astronomer Moulton, a baseball thrown horizontally would go all the way around this moon. The pitcher would thus have time to get a bat and strike at it. "If he missed it he could take his three strikes, then put on his mask, glove and chest protector and catch himself out when the ball came around for the fourth time."

What are Mars' polar caps made of?

Through the telescope, Mars presents a startling resemblance to the earth. Around both its north and south poles is a polar cap. These brilliant white spots spread farther down toward the equator as winter sets in. In the spring they diminish in size, like a knitted

beret that is being unraveled. At the same time a delicate green has been noticed to spread upwards from the equator. And the so-called canals of Mars grow double. The white polar caps or Mars are thought to be made of snow. As the spring advances they are believed to melt and create a supply of water that irrigates the land below.

What are the canals of Mars?

The much-talked-of canals of Mars were discovered by an Italian Astronomer named Schiaparelli. He called them canali, or channels, merely on account of their shape. They are long, dark lines that are supposed to cover the surface of Mars with a fine and complicated network. They cut through the dark greenish places at one time thought to be seas. They intersect the reddish areas or deserts.

Sometimes they are scarcely visible. At other times, especially during the late spring, they grow very distinct. Then they are seen to be double.

From which we gather that if these channels really do exist, Mars is a planet with very little

water. The dark green areas once thought to be seas must be swamp lands of vast extent. The swamps are then watered every spring by the melting polar caps and what Schiaparelli once called canali are more exactly strips of vegetation along the real but invisible canals.

It is hard to believe that Mars' complicated network of canals may be the result of chance. Surely human engineers have had a hand in building this wonderful system of irrigation if such is what it is.

Is Mars a dying world?

Mars is said to be a world "well on in years," a planet much older than the earth. When the earth is as old, its oceans will be dried up, too. Its atmosphere will be as rare, if not rarer. Its mountains and its hills will be worn just as smooth. At least, this is the state of affairs geologists predict for us. They base their judgment upon the past life of our planet. Once there was twice as much water on the earth as there is now. The atmosphere was deeper. The landscape was rougher and sterner. And the climate was mild from pole to pole. Every

minute the earth is losing a little of its vapor. But it is such a very little that millions of years will come and go before any real difference will be noticed.

If we could visit Mars perhaps we should see a civilization much in advance of ours, a prediction of things to come.

Let us be thankful that the day has not yet arrived when a vast swamp connects America with Europe. If water is going to be so scarce as to make water-sports a crime let us hope that the human race will be extinct. We may well pity Mars.

Compared to what Mars may once have been, it is a pitifully dry, hopelessly barren, dying world. Perhaps the Martians look toward our beautiful earth with envy. Perhaps they have already flashed us signals of distress, hoping that some friendly superhuman effort will bridge the tremendous gap of space between us.

Chapter VI

OUR BIG BROTHERS

THE earth's big brothers in the Solar family are the planets, Jupiter, Saturn, Uranus, and Neptune. They are frequently called the superior, major, outer, or Jovian planets. Any one of them is bigger than the entire group of terrestrial planets (including the earth). And they are such vast distances apart that the terrestrial group could sit comfortably between any two of them.

Let us now return to our solar highway. The distance from the sun to the outermost point of the solar system is imagined to be the equivalent of one mile. We find Neptune marking the end of the mile. It is farthest of all from the sun. On the sunward side of Neptune is the planet Uranus. It is two-thirds of a mile along the highway. Saturn is one-third of a

mile from the sun. And Jupiter, the nearest of all the Jovian group, is one-sixth of a mile from it.

In comparison to its big brothers, the earth is close to the heart of the solar system. Its view of the major planets is little different from the sun's. Is it any wonder that astronomers have had such difficulty in learning anything about the members of the Jovian group or that we are not half as well acquainted with them as with the planets, Mercury, Venus and Mars? Does it not rather seem a miracle that we know as much about them as we do?

Which is the largest planet?

Jupiter is much bigger than any of the other planets. He is bigger and heavier than all of the other seven rolled into one. If the sun suddenly ceased to exist, all the planets would be pulled toward Jupiter and would revolve around him. If he wished to pass between the earth and the moon, Jupiter would occupy a third of the distance. Fortunately for the peace and order of the solar system, he does not attempt foreign travels of this nature. If he

came within walking distance of the terrestrial planets, he would kidnap them. They would be added to the nine moons he already has. Like them, they would have to revolve around him as moons.

What are the nine moons of Jupiter?

The nine moons of Jupiter are among the most interesting things about this tremendous planet. When Galileo turned his newly invented telescope toward the heavens, four of Jupiter's moons were the first thing he saw. They seem to be solid bodies like the earth, although Jupiter himself is slightly denser than water, about the consistency of mush. Ganymede, the largest moon, is slightly smaller than Mars. Callisto, the next largest, is somewhat larger than Mercury. Io and Europa, the next in point of size, are about as big as our moon. The five other Jupiterian satellites range in size from one hundred miles across to wee things hardly larger than the baby moons of Mars. If Jupiter and his satellites were to act out the solar system, Jupiter would take the part of the sun. The one-hundred-mile planet, being clos-

est to him, would take the part of Mercury. Io, as the next nearest, would impersonate Venus. Europa would stand for the earth. Ganymede would be Mars. And Callisto would be Jupiter.

Why does Jupiter have a month half a day long?

Some of Jupiter's moons travel more slowly than others. Others have a much bigger circle to cover. So they take different lengths of time to go around him. The one that is slowest and farthest away requires nearly three years to circle around Jupiter. Even so, it moves much faster than our moon when it travels around us. Instead of one month, a Jupiterian has nine types of months to choose from. So according to which satellite you prefer to take as a measure, a month on Jupiter ranges anywhere from half a day to nearly three years.

Is Jupiter inhabited?

Speaking of Jupiterians, we should like to know if this planet is a fit place for life. Life of some sort may exist, perhaps, but not as we know it. In the first place, Jupiter is so far away from the sun that it gets only a fraction as much light and heat. Light twenty-seven candles in a darkened room. Then blow out

all but one. This will show the tremendous difference between the amount of sunlight that reaches the earth and the amount that reaches Jupiter.

Jupiter as it would appear if it were the same distance from earth as the moon

Of course, Jupiter has a very dense atmosphere. In fact, it seems to be all atmosphere. If this atmosphere happens to magnify as well

as bottle up the sunshine, Jupiter may be warm enough to be lived on. But what of the force of gravity? Jupiter's pulling power is more than two-and-a-half times greater than the earth's. A boy weighing one hundred pounds on earth would weigh 265 pounds on Jupiter. We say *on* Jupiter, but it is doubtful if he would be *on* Jupiter for very long. He would be *in* it and sinking rapidly toward the center.

Undoubtedly the rim of Jupiter is composed of lighter material than the earth. But it is still a matter of dispute whether or not Jupiter has a solid core. If it has, then life of some sort may exist. Through a telescope clouds of gas and smoke are plainly visible on the surface of Jupiter. Some astronomers have suggested that this may be an overhead blanket that is shutting in layers of air. If this is the case, the Jupiterians never see the sun at all, even though it rises every ten hours.

What have Venus and Jupiter in common?

Jupiter rotates on its axis faster than any of the other planets. Its day is slightly less than ten hours long. It makes up for a short day and

month by a long year. Traveling steadily over its orbit at a rate of eight miles per second, it manages to complete a circiut of the sun after 10,000 Jovian days. This is a little less than twelve years of our own time. Like Venus' axis, Jupiter's is almost upright on its line of travel. So there is one long unbroken season.

Is Jupiter a world of ice?

Some astronomers believe this one season to be winter. Sunshine alone will not warm Jupiter above the freezing point. If it is heated entirely by the sun, the temperature at the surface of this planet is about 200 degrees below zero. Then there is not, after all, an inner core of heavy material, but a core of ice. On the other hand, Jupiter may not be heated entirely by the sun. Many astronomers believe not. Some say it is still in an early stage of planetary growth and has still to cool off and become solid. Others say it will probably never cool off or become solid.

Certainly the force of gravity on Jupiter is very great. The small particles of matter on the inside of the planet must be weighted by a

tremendous overhead pressure. If this pressure is great enough to break down the atoms it will liberate the electrons just as surely as in the case of the sun. In like manner, a few of these liberated electrons will be turned into heat, while the majority of them will reunite in a gaseous form. According to this theory, Jupiter must lose a large portion of its mass or bulk before it can turn solid. Otherwise the endless chain of condensation, terrific pressure, demolished atoms and liberated energy will go on forever. The chances are against its getting any smaller. More than likely the stray comets and meteors that fall onto this giant planet will make it bigger than ever before.

What does Jupiter look like from the earth?

Whatever the real nature of Jupiter, it is undeniably one of the most impressive lights in our whole night-sky. It appears higher up in the heavens than any of the other bright planets. And it moves with majestic slowness. For this reason it can be seen almost all through the night, as well as almost every night in the year. By midnight it is usually the brightest spot in

the heavens. No doubt you have seen it. It has a golden gleaming yellowish white light. And it shines with steady purpose as though to shame the flickering stars. Watch for it. And the next time you see it, remember that it is a gigantic ball of gas and that traveling round and round it are nine captive moons, so faint as to be completely outshone by their mysterious, powerful master.

Who discovered Saturn's rings?

Galileo, the noted Italian astronomer first to discover the moons of Jupiter, was also the first to discover the now famous rings of Saturn. Saturn's rings are quite invisible to the naked eye. And since telescopes or spy glasses were very scarce in Galileo's time, very few people had any faith in his claim to have seen them. They said "It is a flaw in the great astronomer's glass. No other planet has such handles. Why should Saturn be an exception to the rule? Galileo must be getting old to imagine such things."

What do Saturn's rings look like?

But Galileo was not imagining things, as one will quickly discover by pointing a telescope

Anyone of the great outer planets is larger than the entire group of terrestrial planets

in Saturn's direction. Under a telescope, Saturn, with its rings plainly visible, presents one of the loveliest sights in the whole universe. It is a spectacle that once seen will never be forgotten. Imagine a glowing ball the color of green gold, and around it, circling the equator, a series of brilliant, silvery white rings. These rings are circles of different sizes. They fit one inside of another. They are not very thick, fifty miles at the very most. But they are very broad. The outer edge of the outermost ring is thousands of miles from Saturn's surface. Suppose we could steal the Saturnian rings, setting them around our own less fortunate globe. They would span a third of the distance to the moon. But an easier way to get an idea of their breadth is to fly twice around the earth following the equator.

The innermost ring of Saturn is called the gauze or crepe ring. This is because it has a delicate, almost transparent look. It circles the globe at a distance as far from the surface of Saturn as San Francisco is from Paris. Its

breadth is equal to the distance between Tokio and Lisbon, if one crosses by way of the United States. The crepe ring shades smoothly into a second ring. This second ring is much brighter than the first. It grows increasingly bright until, along its outer edge, it is almost more brilliant than Saturn itself. The outer edge is as sharply cut and as bright as steel. It marks a gap in the rings about as wide as the distance between New York and Salt Lake City. This is called Cassini's division. Cassini is the man who discovered it and saw that it really was an empty ring of space. Outside of this dark intervening gap is the outermost ring. It is a brilliant white circle that extends in width for several thousands of miles, almost equal to half the distance around our earth.

What are the rings made of?

In the meantime, perhaps you have been wondering what these Saturnian rings really are, what they are made of, and why Saturn is the only planet so favored.

Apparently Saturn's rings are just as solid as the planet itself. But this is only because the

earth is so far away that the separate particles in the rings seem like one continuous object. If you look very closely at an oil painting, you will see that it is made up of tiny, separate daubs. At a distance these daubs are hard to tell one from another. They flow together. The rings, then, are made up of individual particles. These particles range in size from grains of dust to life-sized meteors. Each particle moves around the planet with the separateness of a baby moon. Occasionally there are collisions, but very rarely. When they do collide they fuse together. This added weight probably causes them to fall closer to the surface of their planet. Thus particles in the crepe ring are presumably larger than the other particles. When the crepe-ring particles collide they must fall directly upon Saturn. Eventually all the particles may disappear. But it will take millions of years.

How do we know that Saturn is the youngest planet?

Astronomers believe that all the other planets once had rings such as Saturn's. Rings are, therefore, a sign of youth, and Saturn is the youngest child of the sun, a planet prodigy.

Saturn's nine moons are responsible for the gap in the rings. They pull the scattered particles towards them. But they are very small bodies and very far away. Their pull cannot be very great. Still the chances are that if they were any bigger or nearer they would swallow up the rings. Perhaps the space where their attraction is the strongest is thus swept clear.

Why is there a gap in the rings?

If the particles that compose these rings were much farther from Saturn than they are, they would combine into another moon. When the tiny particles drawn away from a liquid planet by the sun do not reach above a certain height, the pulling power of their planet is so strong that it prevents them from joining forces. Collisions between particles is purely accidental. Suppose, on the other hand, that the particles could combine into another moon. What would happen? The moon would fall straight back onto the planet from which it came. The concentrated weight of the particles would work to their disadvantage. It would increase their attractive power.

It is fortunate for Saturn that he does have his beautiful rings. Without them he would be a very plain object indeed. He may be the second planet in point of size and the first in point of lightness, but for all that he is really an ugly duckling without his silvery gold halo. Seen with the naked eye he gives forth a dull yellowish light. Its brilliance, as compared to that of the planets nearer the sun, is drab and lifeless.

When was Uranus found to be a planet?

For thousands of years astronomers looked at Uranus with the greatest indifference. "It is only one of the fainter stars," they thought, "not worth bothering about." Then, one beautiful night, just about a hundred and fifty years ago, something happened that had never happened before. The home-made telescope of a certain German music-master was trained directly on it. Never in all its life had it received so much attention. As though to reward the flattering gaze of William Herschel, it clearly presented the disk-like shape of a planet. But Herschel did not jump at conclusions. He patiently

watched the new planet night after night. Not until he saw that it really had the same wandering nature as the other planets, did he broadcast his discovery.

Why does Uranus shine so faintly?

Uranus, you may remember, is four times as big as the earth, about the size of a medicine ball as compared to a six-inch globe. Why then does its green-white light shine so palely? In the first place, Uranus is so far distant from the Sun that it receives only a tiny fraction as much sunlight as our earth; in fact, the light of one Christmas tree lamp compared with that of 5 five hundred Watt electric lamps (the amount which will flood a tennis court nicely) clearly shows the difference in sunlight. In the second place, this planet is many times farther from the earth than any of the planets we have so far examined.

Why has Uranus such a long year and such a short day?

The distance of Uranus from the heart of the solar system is almost two billion miles. Traveling at the deliberate gait of four and one-fourth miles a second, it takes eighty-four of our years to circle around the sun. Few earth-men live

long enough to ring a Uranian New Year both in and out. Perhaps to make up for the length of this year, Uranus has a very brief day. If we could perch on one of its four baby moons, we might see Uranus turn on its axis once in about every eleven hours. The next time you look at one of our sunsets, remember this. Somewhere on Uranus the sun may also be setting, but for the second time that day.

Are there people on Uranus?

If there are people on Uranus, perhaps they eat their luncheon in the dead of night and go to bed for a long mid-day nap by candle-light. But, of course, there aren't any people on Uranus. It is probably 340 degrees below zero on the surface at noonday. And, like Jupiter and Saturn, this planet is almost entirely a gaseous body.

Can Neptune be seen?

Try, as you may, you will never be able to see Neptune unless you look at it through a telescope. You can see very plainly, then, that it has a disc-like shape and is really a planet. The disc is so tiny that little more can be told about it. No one knows for certain how

quickly Neptune rotates on its axis, though observers at the Lick Observatory have made an estimate of fifteen hours and forty minutes. It is, therefore, quite impossible to tell definitely how long its day and night are. Again, no one knows exactly what sort of an atmosphere it has if it shines entirely by reflected light, if it keeps the same side always toward the sun, or if it has more than one satellite.

What do we know about Neptune?

On the other hand, we know certainly that Neptune, like Uranus, is about four times the size of the earth. This is about the size of all the terrestrial planets and their satellites put together. We know, too, that it is thirty times farther away from the sun than the earth. So it received 1/904 as much sunlight. That is to say, the earth receives about a thousand times as much light as Neptune. But Neptune is hardly in total darkness. Sunlight there, at its brightest, is somewhere between 520 and 700 times as bright as our moonlight. All this light comes from a sun no larger than the disc of Venus, when Venus is nearest the earth.

Why does the sun rise in the west and set in the east?

Neptune is indeed a long way from the other members of the Solar family. He is so far distant that Uranus appears to be the only planet between him and the sun. Even Jupiter and Saturn are quite invisible, and of course Mars, Earth and the other terrestrial planets are so near the sun that they are forever hidden by its glare. Another curious fact about Neptune is its direction of rotation. We do not know definitely the length of Neptune's day, it is true, but we are fairly certain that this planet and its one moon rotate in an opposite direction from the earth, just as Uranus and its satellites do. Thus the sun and moon, instead of rising in the east and setting in the west, rise in the west and set in the east. After her journey through the looking glass, Alice in Wonderland would feel quite at home in a topsy-turvy world such as this.

Do people live on Neptune?

It is unfortunate that Neptune is not a fit world to live in. If it were not for a number of disagreeable features, it would be a fascinating place to visit. One of these bad features is the

temperature which is probably 364 degrees below zero at its surface.

The next drawback is its slight density, one-fifth that of the earth. Whether or not it has a solid core, it is completely enveloped with a cloud-laden atmosphere thousands of miles deep. Unless this atmosphere receives heat from some other source than the sun, and unless it contains breathable substances, it is doubtful if any creatures, no matter how unlike ourselves, could possibly exist. Neptune's one point of similarity to the earth is its force of gravity. Its greater size is offset by its slighter density.

Is there another planet?

For twenty-five years astronomers searched the skies, night after night, in the hope of discovering the mysterious planet X. In 1905 Dr. Percival Lowell noticed that Neptune was sometimes pulled outward by an invisible force. After making a great many calculations he came to the conclusion that a planet beyond Neptune was responsible for its irregular orbit. He was so certain of the existence of this new planet that he devoted much of his time to its discovery.

He even founded an observatory in Flagstaff, Arizona, with this partly in mind.

How was it discovered?

Year after year, the astronomers at Lowell Observatory struggled with the problem. When Dr. Lowell died in 1916, the problem seemed no nearer a solution than before. Then in January of 1930, a strange new disc was noticed on a photograph of the heavens. At first the astronomers thought it might be a comet. But after watching it for a while they came to the conclusion that it was none other than the new planet whose existence Lowell had predicted many years before. Whether these astronomers at Lowell Observatory are correct in believing this object to be the new planet is still open to question. No doubt it will be several years before definite proof can be shown. But in any event due credit should go to the small group of men headed by Dr. V. M. Slipher, who made the suggestion.

What is it like?

They have had some interesting things to tell about the new planet, if such it is. In the first place it is nearly forty-five times as far from the

sun as the earth. The earth receives about two thousand times as much light and heat. Sunlight on Pluto, as it has already been named, is pale and ghostly, no brighter than our dimmest moonlight. The sun itself is a faint pinpoint of light.

The planet receives so little heat from the sun that the nights can be very little colder than the days. The days are about 400 degrees below zero. This is only fifty degrees above the temperature of space.

Astronomers at Flagstaff have still to discover how fast the supposed new planet travels over its orbit around the sun. So no one knows the length of its year. It is fairly certain, however, that a year on a planet of equal distance from the sun is at least three hundred years on our own planet.

Why do we not know more about it?

It will take many years for the astronomers to find answers to all our questions about Pluto. Pluto is a difficult subject. He can be seen with only the finest and biggest telescopes. Tagging bashfully behind his fellow planets he is mak-

ing it as hard as possible for us earth dwellers to know whether he actually is a planet or anything else about him.

Are there other planets?

With Pluto, supposedly the farthest away of the Sun's children, we come to the outermost limits of the solar system. Perhaps there is still another planet beyond X. Astronomers have reason to believe there is. Perhaps you will live to see its discovery. In one way or another you yourself may contribute to the event. There are enough mysteries in the heavens for each one of us to have a separate problem to solve, if we will. The way to begin is to learn to know the heavens; first of all the planets, then the stars.

Chapter VII

AND THEN WHAT?

IN the foregoing chapters we have learned how the earth came to be, how the solar system was created, what the sun is and why it remains so hot. We have also become familiar with the individual members of the solar system, the planets and their satellites. We have seen how each is dependent upon the sun for its place in the heavens, as well as for its light and heat and its habitability. But, you ask, since this wonderful orderly universe has had a beginning, will it also have an end? Astronomers say the solar order will continue evolving from one phase to another, but then what?

It seems probable that as long as the sun continues to exist the planets will revolve around it just as they are doing today. And as long as it continues to shine, they will retain all their

essential features. Nevertheless, there will be some very marked differences. Those terrestrial planets that have atmosphere will gradually lose it, molecule by molecule.

What will become of the earth?

Even the earth will lose its beautiful blue sky, its seas and its rivers. Eventually it will become a dry, barren world with no living thing upon it. In the meantime, the major planets, with the possible exception of Jupiter and Saturn, may have contracted until they are much smaller, and as solid as the earth. In this state they may be able to support an atmosphere such as we have on our globe today. Under these circumstances life may develop. But it in turn will die with the certain loss of planetary atmosphere.

What will become of the sun?

The sun will not grow cold for millions of years hence. Perhaps it never will. As long as the amount of matter it loses through the generation of light and heat is constantly renewed by stray particles from the surrounding space, there is no reason to imagine that it will ever die away. Is it not just as reasonable to

suppose that the sun will plunge into an even denser region of nebulous material as to suppose that it will wander into a sparse or arid zone?

Let us see what would happen to our solar system in either case. If the sun should travel through an unusually rich nebulous region it would become bigger and brighter. And the planets would become bigger, too. Jupiter and Saturn, being the largest of the eight, would attract most of the sun's leavings to themselves. The fatter they grew the more they would attract. Eventually they might approach the dimensions of a baby star and burst into light and heat. In the meantime their distance from the sun would have diminished. If, in consequence, they did not swallow up the other planets they would certainly push them into the sun. Then, if Saturn were thrown in too, Jupiter would be the only one left to tell the tale. He and the sun would probably form a double star.

Now let us suppose the very opposite. The

sun, instead of traveling through the fertile fields of space, might be side-tracked in a region which is practically empty. It would gradually grow smaller. It would begin to condense and its light slowly fade, then die out. But all this would occupy millions of years. During the last million the sunny side of Mercury would develop a very agreeable climate. It might even be possible for it to retain an atmosphere. Life might then commence, only to flourish and die just as it had on the other planets.

What would become of the solar system?

When the last spark of life has been extinguished on the planets, and the last ray of sunlight has died out, the obedient children of the Sun will continue to revolve around him. Cold and lifeless, invisible as the sun they circuit, they will stumble on through darkest space, their paths lit only by the pale light of distant stars. This would indeed be the end of present glories, a ghostly living death. Let us hope for an ending more magnificent.

Will new worlds be created?

Today the sun is sweeping through space at a rate of eleven miles a second or about four

hundred million miles a year. It carries the earth and the other planets along with it. As far as we can tell it is making straight for the beautiful Vega, the fourth brightest star in the heavens. But the distance is so great that it

Eventually the world will die out and become a dry barren thing with no life upon it

will require millions of years for the two to come together. In the meantime they may both have altered their courses, or on coming closer find that they are going to pass each other billions of miles apart.

The last time our sun met another star was some ten or twenty billion years ago. Astronomers tell us that such an approach occurs once in about four millions of billions of years. So we may reasonably expect another encounter in no less than three quintillion, nine hundred quadrillion years from the present.

Of course our sun may have turned cold long before. But for that matter it may have turned cold any number of times and each time been brought back to light and heat by the simple process of wandering into another richly nebulous region. In any event, when it does rub elbows with a visiting star, a second solar system will probably be born. Then those members of our present system which still exist will divide and recombine with one another, to become a family of new planets. The new planets will revolve around a new sun in a different part of the heavens. A new order of progress will be evolved. Life will then commence, to die and recommence somewhere else. Thus will our well-loved solar system be perpetuated.